INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 11, No. 2, p. 68-76, 2017

RESEARCH PAPER OPEN ACCESS

Effect of phospho-potassium fertilization on yield of Deglet Nour date palm grown in gypsum soil and irrigated with salted water (Biskra southeast Algeria)

Ouamane Rim*[1], Reguieg Yssaad Houcine Abdelhakim[2], Masmoudi Ali[3]

[1]*Department of Agronomy, University of Mostaganem (UMAB), Mostaganem, Mostaganem, Algeria*

[2]*Department of Biology, University of Mostaganem (UMAB), Mostaganem, Mostaganem, Algeria*

[3]*Department of Agronomy, University of Biskra, Biskra, Biskra, Algeria*

Key words: Date palm, Fertilization, Salinity, Potassium, Phosphorus

http://dx.doi.org/10.12692/ijb/11.2.68-76 Article published on August 20, 2017

Abstract

A field of study was carried out during the two consecutive years (2015-2016) on 30 years old Deglet-Nour cultivar that was grown in gypsum soil and irrigated with salt water which caused serious problems of soil salinity. Palms were fertilized with three levels of potassium (0, 2 and 3 kg /palm) as potassium sulphate K_2SO_4 (50%) combined with three levels of phosphorus (0, 1 and 2 kg/palm) as superphosphate (TSP) in order to study their influence on the yield, fruit quality and the necessary duration for the responses of palm tree to these fertilizing elements in such conditions. Data showed that applying 2 kg of potassium combined with 1 kg of phosphorus increased the yield and gave better results of fruits weight, length, diameter and weight of pulp. Fruits' chemical characteristic also improved by the same treatment after two years of the study.

* **Corresponding Author:** Ouamane Rim ✉ rim1070@hotmail.fr

Introduction

Date palm (*Phoenix dactylifera* L.) is one of the oldest and most important fruits in the world. It is also the pivot of the Saharan ecosystem and the base of the existence and durability of its oases. With more than 17 million palms trees and more than 800 varieties, Algeria occupies an important place among the countries that produce and export dates around the world. Moreover, it ranks first in terms of quality thanks to Deglet-Nour cultivar that is considered as the most economically important cultivar ever grown in Algeria. Palms of the present study are growing in gypsum soil and irrigated with salted phreatic water.

These latter conditions have a great influence on nutrient uptake validity. Florea and Al-journaa (1998) stated that high gypsum content affects the mobility and availability of P, K, Mg, Fe, Mo, and Zn for plants and decreases the growth and crop yields (Cairns *et al.*, 1981; Mashali, 1996).On the other hand, mineral salts dissolved in irrigation water causes harmful effects to plants; Munns and Tester (2008) mentioned that there are two types of salinity affects;firstly, the adverse osmotic effect, which is the presence of high concentrations of salts in the soil solution making it harder for roots to extract water and reducing the ability of the plant to take it up, leading to slower growth. Osmotic stress arrests the growth of plant and affects cell division and elongation.

The division of cells is a crucial process which determines the meristem activity and the overall plant growth rate (Bartels and Sunkar, 2005).,Secondly, the toxicity effects; which are the presence of high concentrations of salt in plants (intracellular and intercellular) which can be toxic and lead to cellular damage (Munns, 2005). Increasing of soil salinity is starting to show negative impact on the date palm agro-ecosystem in arid region, especially in the Middle East (Dakheel, 2005).

Accurate information about the growth of date palm in saline environment and the variability in salt tolerance among cultivars is largely unknown. Thus, a serious attention is needed to maintain the diversity and growth of such plants in the arid region (Mouhamed *et al.*, 2012). Ttherefore, the adaptation of a proper fertilization programs in terms of adequate rates and appropriate sources are important strategies for better yields (Fagria and Baligar, 2005). Agronomic researches on the fertilization of the date palm are still limited, especially the test of Phosphorus and Potassium fertilization.

In the Algerian phoenicicol zone, the date producers use manure as a principal fertilizing contribution to the palm tree. Yet, lately, with the increase of soil salinity by the irrigation water and capillary upwelling, the addition of organic manure became insufficient to obtain a better quality of date. The present study was carried out to investigate the efficiency of using different levels of Potassium and Phosphorus fertilization on yield and fruit quality of Deglet-Nour dates grown in gypsum soil and irrigated with salted water.

Material and methods

Plant material, treatments and experimental design

The present study was conducted during the successive seasons of 2015 and 2016 in private orchard located in Biskra in the southern east of Algeria on 30 years old Deglet Nour date palm. For this purpose, the salinity map was established to study the spatial distribution of salinity in the orchard in order to select the suitable site for the study; The thematic map of the "CE" is interpolated with spatial analyst of Surfer 14 (Golden Software, LLC)(Fig.1), then twenty seven trees were chosen as uniform as possible, healthy of any infection, subjected to the same cultural practices, palm tree were planted at spacing 9x9 meters apart and irrigated by drip system. Analysis of the experimental orchard soil as presented in Table (1).

The palm was fertilized with superphosphate (46%) as a source of phosphorus and potassium sulphate (K_2SO_4 50%) as a source of potassium. Nine soil application treatments were arranged in completely randomized design with three replicate (1replicate = 1 palms) per treatment (i.e. 1x3x9 =27), the treatments were as follow:

T1: unfertilized tree (control),T2: 0kg K + 1kg P,T3 : 0kg K + 2kg P,T4 : 2kg K + 0kg P,T5: 2kg K + 1kg P,T6: 2kg K + 2kg P,T7: 3kg K + 0kg P,T8: 3kg K + 1kg P, T9: 3kg K + 2kg P.

The treatments were added in either one dose to a depth of 40cm from the soil surface and 50 cm apart from the palm trunk.

Yield determination

The average fruit yield was recorded in kilograms. Additionally, fruit samples were randomly taken from different branches to determine the values of physic-chemical characteristics chosen to represent fruit quality.

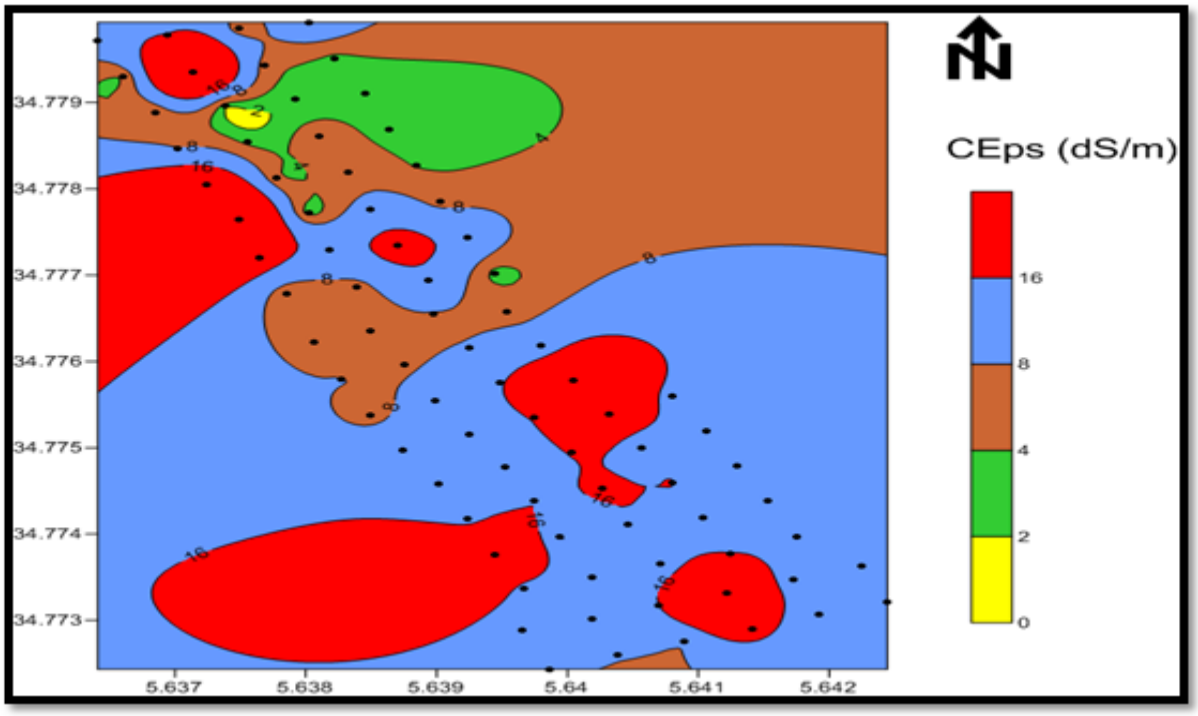

Fig. 1 . Salinity map of the study area (interpolation of the EC).

Fruit physical characteristics

Sample of 20 fruits have been taken on each palm tree for the determination of the physical characteristics (weight, diameter and length of fruit, weight of pulp and weight of stone).

Fruit chemical characteristics

Sample of 20 mature dates for each replicate was used to determine the chemical characteristics of fruit. The fruits were cut into pieces with a clean knife; five grams were taken from the fresh fruit to extract the reducing carbohydrates with water at 85°C and the 3,5- dinitro salicylic acid to extract sugar (Barbin, 2006). The percentage of reducing sugar and the amount of total carbohydrates was determined according to AOAC (1995). The acidity (as malic acid) was determined according to AOAC (1995).

Fruit moisture and mineral contents

A 20 fruit sample from each replicate was taken and washed with tap water, rinsed twice in distilled water cut into small pieces with a clean knife. Then, an amount of the fresh sample was weighed (fresh weight) and dried to a constant weight (g) in air drying oven at 70 ◦C, then weighed (dry weight). Fruit moisture was calculated as follows:

$$\text{Fruit moisture content (\%)} = \frac{\text{average fresh weight} - \text{average dry weight}}{\text{average fresh weight}} \times 100$$

Dried fruits were digested with H_2O_2 and H_2SO_4 according to Evanhuis and Waard (1980).Phosphorus was determined by the ascorbic acid method according to Murphy and Riley (1962). Potassium was determined with a flame photometer.

Statistical analysis

All data were tested by analysis of variance (ANOVA) technique by Xlstat 2016 (Addinsoft, 2016 data analysis and statistical solution for Microsoft excel). Treatments means were separated and compared using the significant differences at 0.05 levels of significance according to Snedecor and Cochran (1989).

Results and discussion

Yield

Data in the Table 2 indicated that the yield of date palm was significantly affected by the treatments of Deglet Nour cultivar in two seasons of study. In this respect, the highest yield was obtained from T2 and T5 in the first season. While in the second season, T5 treatment gave better yield. On the other hand T7, T9 and T3 gave the lowest yield in the first season, as well as T8 and T9 treatment in the second season.

Table 1. Analysis of the experimental orchard soil and irrigation water.

properties	Orchard soil depth		
	0-45	45-80	80-120
EC (ds/m)	11.65	8.92	9.57
pH	07.66	08.41	9.57
Na(meq/l)	62.44	35.3	14.08
Ca(meq/l)	0.6	15	4.8
Mg (meq/l)	48.8	16.4	26.4
K (meq/l)	3.2	2.44	0.54
Cl (meq/l)	86	84	41
SO_4 (meq/l)	19.17	18.15	16.03
HCO3(meq/l)	2	3	2
$CaCo_3$ %	0.05	0.04	0.1
Gypsum%	65.51	66.15	66.15
$EC_{irrigationwater}$ (ds/m)	5.5	/	/

The results obtained are in agreement with the results of El Hammady *et al.* (1991) who found that the highest yield and quality of dates (Seewy) were obtained by the addition of 2 kg of Potassium sulfate/palm/year. Bamiftah *et al.* (2000) recommended 2 or 3 kg of potassium sulfate/palm/year for high yield. These results can be attributed to physiological role of potassium in the improvement of many metabolic processes such as formation of carbohydrate. Archer (1986), Even and Sorger (1996) reported that photosynthetic translocation depended on the cell concentration of Potassium. Phosphorus is necessary in metabolic processes: the synthesis of proteins and energy of ATP as support of Adenosine (Mengel and Kirbry 1978). The increase in yield of palm trees by the use of phosphate fertilizers was also reported by Bliss and Mathez (1983), Sabah (1993), Karami (2007).

Fruit physical characteristics

The data in Table 2 showed that some parameters of the quality of Deglet-Nour dates were affected by the treatments. Results tabulated in Table 2 indicated that the average weight of fruit and weight of pulp significantly increased by most treatments compared to the control T1 in first season. However, palm tree treated by T5 treatments gave the highest weight and weight of pulp also in T8 treatment. In this respect, the control T1 and T2, T3 gave the lowest treatments and recorded the lowest value in the second season.

Data in Table 2 indicated that fruit length was significantly affected by the treatments for Deglet-Nour date palm in both seasons of study. In the first season, the best results were obtained from T5 and T4 while in the second season T5 and T8 treatments gave the longest fruits compared to the control T1 that gave shorter fruits in both seasons.

The average fruit diameter presented in Table 2 indicated that the highest value in first season was obtained by T8, T4 and T6 and the lowest value was obtained by T2 and T3. In the second season, the tree treated by T5 gave the best diameter with 1.93 cm compared to the control and other treatments.

Table 2. Effect of levels potassium and phosphorus fertilization on fruit physical properties of Deglet–Nour date palm cultivar during 2015-2016 season.

Treatments	Yield (kg/palm)		Fruit weight (g)		Fruit diameter (cm)		Weight of the stone (g)		Weight of pulp (g)		Fruit length (cm)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
T1	88.00^{BCDE}	81^{BCDEF}	7.92^{F}	8.06^{F}	1.5^{DE}	1.29^{E}	0.84^{BCD}	0.75^{D}	7.08^{F}	7.31^{EF}	3.57^{EF}	3.45^{F}
T2	97.33^{BC}	97.00^{BC}	8.15^{EF}	10.17^{ABCD}	1.49^{DE}	1.69^{BCD}	0.81^{CD}	0.88^{ABC}	7.34 ^{EF}	9.29 ^{ABCD}	3.61^{DEF}	3.80^{BCDE}
T3	65.00^{EF}	97.00^{BC}	8.17^{EF}	10.64^{ACDE}	1.47^{DE}	1.67 ^{BCD}	0.85^{ABCD}	0.96^{A}	7.33 ^{EF}	9.68 ^{ACDE}	3.69^{CDEF}	3.94^{ABC}
T4	84.67^{BCDE}	97.33^{BC}	9.19^{CDEF}	11.51^{AB}	1.53^{CD}	1.76^{AB}	0.85 ^{ABCD}	0.90^{ABC}	8.34 ^{CDEF}	10.61 ^{AB}	3.84^{ABC}	3.89^{ABCD}
T5	94.00^{BCD}	127.00^{A}	9.29^{CDEF}	11.98^{A}	1.51^{CDE}	1.93^{A}	0.85 ^{ABCD}	0.90^{ABC}	8.44 ^{CDEF}	11.08^{A}	3.81^{BCDE}	4.12 ^{A}
T6	78.67^{BCDE}	98.67^{BC}	9.35^{DEF}	9.86^{BCDEF}	1.53^{CD}	1.64^{BCD}	0.81 ^{BCD}	0.89^{ABC}	8.54 ^{DEF}	8.97 ^{BCDEF}	3.72 ^{CDEF}	3.80^{BCDE}
T7	60.00^{F}	99.00^{B}	8.73^{CDEF}	10.96^{ABC}	1.51^{DE}	1.73^{ABC}	0.89 ^{ABC}	0.93^{AB}	7.84 ^{CDEF}	10.03 ^{ABC}	3.69 ^{CDEF}	3.88^{ABCD}
T8	71.67^{DEF}	76.33^{BCDE}	8.94^{DEF}	11.74^{BCDEF}	1.53^{BCD}	1.77^{AB}	0.87 ^{ABC}	0.96^{A}	8.07 ^{DEF}	10.7 ^{DEF}	3.73 ^{CDEF}	4.07^{AB}
T9	61.33^{EF}	87.33^{CDEF}	8.66^{BCDEF}	9.80 ^{BCDEF}	1.51^{DE}	1.60^{BCD}	0.79 ^{CD}	0.83^{BCD}	7.87 ^{BCDEF}	8.97 ^{BCDEF}	3.68^{CDEF}	3.86^{ABCDE}
Mean	78.33^{B}	95.18^{A}	8.71^{B}	10.52^{A}	1.50^{B}	1.67^{A}	0.84^{B}	0.89^{A}	7.87^{B}	9.63^{A}	3.70 ^{B}	3.87^{A}

The total improvement in physical characteristics could be explained by the role of potassium. The increase in weight of the fruit can be attributed to the physiological effect of potassium in increasing the osmotic potential of fruit cell which could promote the circulation of water in fruit and consequently its volume and weight. These results are in agreement with Houssine *et al.* (2012) who reported a spray application of fruit with 2% potassium, caused an increase in fruit weight, volume and concentration of potassium in fruit varieties "Halawy". Dialmi and Rezhman (2005) affirmed that foliar application of pure potassium sulfate (5kg/1000L) improved yield and other characteristics such as fruit weight, length, diameter, and pulp weight of the date variety 'Toory'. Fisher *et al.* (1959) have mentioned that potassium is essential for the enlargement of fruit.

Fruit chemical characteristics

The results in Table 3 indicate that the general trend shows that fertilization affected the percentage of total carbohydrates, reducing sugar and total fruit acidity percentage. In the first season, the best results were obtained from T3 followed by T5 and T4. While in the second season, T5 and T8 treatment gave the highest percentage of total carbohydrates compared to the control T1 and other treatments.

Moreover, T7 gave the highest fruit content of reducing sugar in first season and T5 in second season. However, the differences were not so significant between various treatments. This is probably due to the fact that dates have not reached full maturity unlike what appears on the outside of those dates in complete growth; because the increase in carbohydrates is one of the chemical changes which accompany maturity (Burton, 1982; Booij *et al.*, 1992). Indeed, the increase of accumulation of reducing carbohydrates occurs at the last stage because the over-activity of the invertase enzyme which affects the conversion of sucrose into reducing sugars (glucose, fructose) in addition to the transmission of sucrose from the upper part of the palm tree to fruits and the continuity of flow of carbohydrates transformed in leaves towards the fruits (Shabana, 2006).

Similar results were found by Hussein *et al.* (1977) on the Khunaizi and Sukkari varieties and Bacha *et al.* (1982) on the Khudari variety on the one hand and Furr *et al.* (1955) on the other hand on Deglet Nour variety who found that the quality of fruit trees fertilized by mineral element was not significantly different from that of control palms.

However, these results do not agree with those of Al kharusi *et al.* (2009), Saleh (2009), Dialami and Mohebi (2010) who reported that the sugar content and acidity are positively affected by fertilizer application.

Moisture and fruit mineral content

Moisture is the main value in the chemical composition. The results obtained show a significant increase in water content in the fruit of second year.

This shows that the effect of mineral fertilization on palm trees will be more apparent from the second year.

Table 3. Effect of levels potassium and phosphorus fertilization on fruit physical properties of Deglet –Nour date palm cultivar during 2015-2016season.

Treatments	Total sugar %		Reducing sugar %		Non Reducing sugar %		Acidity%		Moisture %		Phosphorus %		Potassium %	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
T1	70.68$_{AB}$	69.31$_{ABC}$	28.06$_{CD}$	30.05 $_{CD}$	42.62$_{ABCD}$	39.26$_{ABCD}$	5.1 $_{ABC}$	2.57 $_{C}$	10.47$_{D}$	24$_{BC}$	0.28$_{E}$	0.44$_{BCD}$	1.02$_{BCD}$	0.46$_{D}$
T2	69.11$_{ABC}$	71.94$_{A}$	27.86 $_{CD}$	34.75 $_{ABCD}$	41.25 $_{ABCDE}$	37.19$_{ABCD}$	5.03 $_{ABC}$	3.47 $_{AB}$	10.6 $_{D}$	22.67 $_{BC}$	0.3$_{DE}$	0.5 $_{AB}$	1.1 $_{AB}$	0.53 $_{D}$
T3	73.05$_{A}$	68.2$_{ABC}$	30.43$_{BCD}$	24.08 $_{D}$	42.62 $_{ABC}$	44.12$_{ABCD}$	5.6 $_{ABC}$	7.6 $_{ABC}$	8.73 $_{D}$	.67 $_{BC}$	0.31 $_{DE}$	0.56 $_{AB}$	0.98 $_{AB}$	0.41 $_{D}$
T4	71.9$_{A}$	69.38$_{ABC}$	28.95 $_{CD}$	38.08 $_{ABCD}$	42.95$_{A}$	31.3 $_{ABCDE}$	6.53 $_{ABC}$	4.73$_{ABC}$	8.87 $_{D}$	27.33$_{A}$	0.28 $_{E}$	0.48 $_{BC}$	0.99 $_{BC}$	0.55 $_{D}$
T5	71.95$_{A}$	75.89$_{A}$	30.65$_{BCD}$	55.44 $_{A}$	41.3 $_{DE}$	20.45 $_{CDE}$	6.23 $_{ABC}$	4.87$_{ABC}$	10.67 $_{D}$	30.67 $_{ABC}$	0.34 $_{CDE}$	0.51 $_{AB}$	1.06 $_{AB}$	0.4 $_{D}$
T6	68.74$_{ABC}$	71.97 $_{A}$	20.87 $_{D}$	25.26 $_{D}$	47.87 $_{ABCD}$	46.71$_{AB}$	5.37 $_{ABC}$	6.9 $_{ABC}$	10.87$_{ABC}$	26.67$_{ABC}$	0.32$_{CDE}$	0.47 $_{BC}$	1.00 $_{BC}$	0.46 $_{D}$
T7	69.09$_{ABC}$	72.01 $_{A}$	48.54$_{ABC}$	52.68 $_{CD}$	20.55 $_{ABCD}$	19.33$_{E}$	6.47$_{ABC}$	8.17 $_{A}$	7.2 $_{D}$	25.33$_{ABC}$	0.23 $_{E}$	0.65$_{A}$	1.2$_{A}$	0.55 $_{D}$
T8	62.53$_{C}$	73.64 $_{A}$	28.73$_{CD}$	50.06 $_{ABC}$	33.8 $_{ABCD}$	23.58$_{ABCD}$	6.1 $_{ABC}$	4.2 $_{ABC}$	6.13 $_{D}$	22$_{C}$	0.26 $_{E}$	0.54 $_{AB}$	1.08 $_{AB}$	0.42 $_{D}$
T9	63.75$_{BC}$	69.16$_{ABC}$	29.24$_{CD}$	36.33 $_{ABCD}$	34.51 $_{ABCD}$	32.83$_{ABCD}$	5.2 $_{ABC}$	2.7 $_{C}$	8.93 $_{D}$	23.33$_{BC}$	0.31 $_{DE}$	0.52 $_{AB}$	0.92 $_{AB}$	0.51 $_{D}$
Mean	68.98$_{A}$	71.27$_{A}$	30.32$_{B}$	38.52$_{A}$	32.75$_{A}$	37.60$_{A}$	5.02$_{A}$	5.73$_{A}$	9.16$_{B}$	25.63$_{A}$	0.29$_{B}$	0.52$_{A}$	1.04$_{A}$	0.47$_{B}$

The treatment application 2 kg of potassium sulfate and 1 kg of TSP marked very high moisture content with a percentage 30%. Our results are similar or higher than those reported by other researchers in other countries (Youssif *et al.*, 1989; Ahmed *et al.*, 1995; Aidoo *et al.*, 1996; Al-Shahib and Marshall, 2003).

The results obtained indicate also a significant increase in the Phosphorus concentration contained in the dates of the second season. However, statistical analyses show a significant difference between treatments on Phosphorus concentration, the highest value is marked by the treatment T7 with 0.65%. The results show that the phosphorus concentration in fruit increased significantly after the addition of potassium sulfate, these results agree with those of Kassem *et al.* (1997) and Kassem (2012) who reported that the content in N, P, K, Fe, Zn in leaves and fruits increases with the application of potassium which strongly influences nutrient absorption as well as translocation and distribution of other cations (Epstein, 1972). In other hand, the plant use of Phosphorus brought by manure is minimal compared to the phosphorus of soil reserve (Castillon *et al.*, 1995).

It also seems that the addition of Potassium stimulates the absorption of Phosphorus of this reserve compared to the Phosphorus of the manure which is exposed to problems of precipitation in calcic medium (Dutil, 1976; Barber, 1977; Arvieu, 1980; Masmoudi, 1998).

The results of Potassium analysis show a significant reduction in potassium rate in fruits of second season which seems to be due to the incompleteness of maturation of dates (as indicated previously) and by the role of this element in the complete maturation of fruits.

The reduction of Potassium in parallel with the notable increase of sugars contained in dates is due to the role of potassium in the composition of sugars and thus its contribution to the full maturity of fruits. Abbas and Fares (2008) have mentioned that potassium is necessary for the formation of sugars, synthesis of proteins, cell division and growth fruit formation and productivity.

Conclusion

The results of this research have shown that the introduction of these essential elements in nutrition of date palm Deglet-Nour variety had a considerable effect on production and quality of the fruit. Consequently, the determination of the optimal amounts of these elements and their application to this cultivar is necessary and could generate significant revenues for farmers.

Finally, we can conclude by saying that the additions of phospho - potassium manure have an appreciable effect on the chemical components of fruits (total carbohydrates, reducing sugar and acidity) from the second year.

The addition of 2 kg of potassium sulfate by palm in a very salted medium and with 1 kg of TSP significantly improves moisture, date weight, Length, diameter, pulp weight and weight of stone.

Acknowledgements

First of all, thank God for having given me strength and will to pursue this work. Then I would like to thank my teachers Pr. H. Reguig and Dr. A. Masmoudi. I'm also thankful to Dr. Abd Hafid Youssif, Mr. Ouamane Tarek and Mr. Hadoud Nadjib for their expert advice and encouragement throughout this difficult project.

References

Abbas F, Fares A. 2008.Best management practices in citrus production. Tree Forestry Science and Biotechnology **3,** 1-11.

Ahmed IA, Ahmed AWK, Robinson RK. 1995. Chemical composition of date varieties as influenced by the stage of ripening. Food Chemistry **54(2),** 305–309.

Aidoo KE, Tester RF, Morrison JE, MacFarlane D. 1996. The composition and microbial quality of pre-packed dates purchased in Grater Glasgow. International Journal of Food Science and Technology **31(1),** 433–438.

Al-Kharusi LM, Elmardi MO, Ali A, Al-Julanda F, Al-Said L, Abdelbasit K, Al-Alpha JM, Chen J, Zhang G. 2009. Effect of nitrogen fertilizer forms on growth, photosynthesis, and yield of rice under cadmium stress. Journal of Plant Nutrition **32(2),** 306-317.

Al-Shahib W, Marshall RJ. 2003. The fruit of the date palm. International Journal of Food Science and Nutrition **54(4),** 247–259.

Anonyme, 1985. La fertilisation. Fédération national de l'industrie des engrais, 74p.

AOAC. 1995. Association of Official Agricultural Chemists, Official Methods of Analysis, 15th ed. A.O.A.C., Washington, DC.

Archer J. 1985. Crop nutrition and fertilizer use. Farming Press XL td. 258 p.

Bacha MA, Abo-Hassan AA. 1982. Effects of soil fertilization on yield, fruit quality and mineral content of khudari date palm variety; first symposium on date palm Arabia Saudi P 174-179.

Bliss E, Mathez E. 1983. The Arkell date garden fertilizer experiments. Date growers Institute **22**, 25-33.

Bamiftah MAO. 2000. Effect of potassium fertilization and bunch thinning on yield and fruit quality of 'Zaghloul' date palm. M. Sc. Thesis, Faculty of Agriculture Science, Saba Basha, Alex. University.

Barbin P. 2006. Contrôle et Elements De Maitrise De La Contamination Par La Levure Brettanomyces Au Cours Du Procedéde Vinification En Rouge: 257. Thèse de doctorat de l'institut national polytechnique de toulouse, France.286 p.

Bartels D, Sunkar R. 2005. Drought and salt tolerance in plants. Crit. Review. Plant Science **24(1),** 23–58.

Booij I, Piombo G, Risterucci JM, Coupe M, Thomas Merry D. 1992. Study on the chemical composition of dates at different stages of maturity for the varietal characterization of various cultivars of date palm (*Phoenix dactylifera* L.). Fruits **47,** 667-678.

Burton WG. 1982. Postharvest physiology of food crops Longman, New York 310p.

Cairns RR, Lavado RS, Webster GR. 1981 - Yield depression caused by gypsum applied in combination with NH4 NO3, to a Solonetzic soil. Investigaciones Agricolas **16,** 1-10.

Castillon P, Colomb B, Decroux J, Diab M, Fardeau JC, Laurent F, Masse J, Plet Villemin P. 1995. Aide au diagnostic et a la prescription de la fertilisation phosphatée et potassique des grandes cultures. Comifère.3-23.

Dakheel A. 2005. Date Palm Tree and Biosaline Agriculture in the United Arab Emirates. In: The Date Palm: From Traditional Resource to Green Wealth. UAE Center of Studies and Strategy Researches, Abu Dhabi, UAE .247-263.

Dialami H, Pezhman H. 2005. Effects of potassium sulfate, potassium nitrate and manganese sulfate on yield and fruit quality of 'Toory' date palm cultivar grown in Iran. Iran, Hormozgan Province. First international festival and symposium on Gdate Palm,P4.

Dialami H, Mohebi AH. 2010. Increasing yield and fruit quality of date palm 'Sayer' with application of nitrogen, phosphorus and potassium optimum levels. Acta- Horticulture **88(2)**, 353- 360.

El- Hammady AM, Khalifa AS, Montasser AS. 1991. Effect of potash fertilization on 'Seewy' date palms. Effect on yield and fruit quality. Egypt. Journal Horticulture **18(2),** 199-210.

Epstein E. 1972. Mineral nutrition of Plants- Principles and Perspective. John Wiley and Sons. Inc. New York.412 p.

Evans HJ, Sorger GJ. 1966. Role of mineral-elements with emphasis on the univalent cations. Annual Revew. Plant Physiology **17,** 47-76.

Evenhuis B, Waard PWF. 1980. Principles and practices in plant analysis, Royal Tropical institute., Amsterdam (Netherlands).

Fageria NK, Baligar VC. 2005. Enhancing nitrogen use efficiency in crop plants. Advances in Agronomy **88**, 97-185.

Fisher EG, Parker KG, Luepschen NS. 1959. Proceedings of the American Society for Horticultural Science, 78-90.

Florea N, Al-Joumaa Kh. 1998. Genesis and classification of gypsiferous soils of the Middle Euphrates floodplain. Syria. Geoderma **87**, 67-85.

Furr JR, Currlin EC, Hilgeman RH, Reuther W. 1955. An irrigation and fertilization experiment with Deglet Noor dates. Date Growers' Inst. Rep **28**, 17-20.

Hussein F, Moustafa S, EI Samiraie F, Mahdi M. 1977. Effect of Nitrogen fertilization on growth, yield and fruit quality of dates grown in Saudi Arabia. Res. Bull. No.12. Ministry of Agriculture and Water, Research and Development Department, Saudi Arabia.

Karami Y. 2009. Effect of Nitrogen, Phosphorus and potassium fertilizers on date palm, cultivar 'Sayer'. Final report of research design, Agricultural Research, Education and Extension Organization, Iran.

Kassem HA, El-Shabrout MB, Attia MM. 1997. Effect of nitrogen and potassium fertilization on yield fruit quality and leaf mineral content in some Egyptian soft date varieties. Alex. Journal of Agricultural Research. **42(1),** 137-157.

Kassem HA. 2012. The response of date palm to calcareous soil fertilization. Journal of Soil Science and Plant Nutrition, **12 (1),** 45-58.

Klein P, Zaid A. 2000. Date palm fertilization: Udapted information for modern Date cultivation in Namibia,189-194.

Mashali AM. 1996. Soil management for gypsiferous soils: A revew. Proceedings of International Symposium on soils with gypsum. Lleida, 15-21 sep. Edicions Universitat de Lleida. Lleida, Spain, 203 p.

Mengel K, Kirkby E. 1978.Principles of plant nutrition International Potash Institute, Worblaufen-Bern, Switzerland,419-431.

Mohamed S, Alhammadi, Shyam Kurup S. 2012. Impact of Salinity Stress on Date Palm (*Phoenix dactylifera* L): A revew. Crop Production Technologies: Peeyush Sharma, 169-179.

Munns R, Tester M. 2008. Mechanisms of Salinity Tolerance. Annual Reviews Plant Biology, **59,** 651-681.

Munns R. 2005. Genes and salt tolerance: bringing them together. New Phytol. **167(3),** 645–663.

Murphy J, Riley JP. 1962. A modified single solution method for the determination of phosphate in natural waters. Analytica Chimica Acta **27,** 31-36.

Saleh J. 2009. Yield and chemical composition of 'piarom' Date-Palm *Phoenix dactylifra* as affected by nitrogen and phosphorus levels. International Journal of Plant Production (IJPP), **2,** 57-64.

Shabana Hassan AR, Abd wahab Z, Abd al kader IS. 2006. Physiology and production of Date palm, protection after production. Food and Agriculture Organization of the United Nations Rome Italy, 132 p.

Youssif AK, Morton ID, Mustafa AI. 1989. Studies on date paste. I. Evaluation and Standardization. In: Proceedings of the Second Symposium on the Date Palm in Saudi Arabia. King Faisal University, Al-Hassa. Riyadh, Saudi Arabia: Mars Publishing House, 85–91.